services are currently priced well above cost by telephone operators. Competition would drive these prices to cost.

The business case assumes that the cable company is in the long distance resale business and that 50 percent of the cable telephony customers purchase resold long distance customers from the cable telephony operator. Access and resold long distance minutes are assumed to grow by 7 percent per year throughout the study period.[56] The margin on long distance resale is assumed to be $.015 per minute.[57]

Monthly service charge revenues are based on the national average rate of $19.00.[58] This amount was not discounted even though a recent Yankee Group study found that local service charge discounts of 10-15 percent are required in order for cable operators to attract 21.5 percent of current ILEC local exchange subscribers.[59]

The current national average access charge is approximately 3 cents per minute.[60] This amount is used to determine year one access revenue. The FCC is currently considering access

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[56] See FCC, Trends in Telephone Service (May, 1996).

[57] IXCs are advertising residential long distance calling plans with rates between $.10 and $.15 per minute. The margin used in this analysis is a function of three parameters: an assumed average residential retail long distance rate of $.125, an SG&A expense of 17 percent of revenue, and long distance minutes purchased from a carrier at a rate of $.09 per minute. See, Merrill Lynch, U.S. Telecom Services -- Long Distance -- Third Quarter Review (November 13, 1996), p.11.

[58] In October 1994, the national average for flat-rate residential service was $19.00 monthly, including taxes and subscriber line charges. See Trends in Telephone Service, *supra.*, note 56.

[59] See, The Wall Street Journal, *supra.*, note 51. Furthermore, this is consistent with *ELB-I* survey results. See, The Enduring Local Bottleneck, *supra.*, note 4, p. 110.

[60] See, Trends in Telephone Service, *supra.*, note 56.

charge reform proposals that would bring access charges to cost.[61] The business case assumes that by the fifth year of the study period, access charges will be priced at the TSLRIC cost estimated in the Hatfield Model.[62]

As discussed in Section V, the modeling focuses on residential competition. It may be possible for cable operators to attract businesses in the territories they serve to use cable telephony. Businesses pay relatively more for basic telephone service than residential customers and tend to use more long distance services per line. This would add substantial revenues to the telephony business case. However, the business case results discussed below would not necessarily change. First, like residential rates, business rates could be expected to fall to cost over time. Second, serving business customers would involve investment in drops and would likely involve substantial additional infrastructure construction.

Cable telephony penetration will depend on a number of factors including cable company pricing policy, ILEC pricing, marketing effort, and consumer willingness to change suppliers at various price levels. We have computed the business case for cable telephony under three alternative end of period penetration assumptions: 10, 20 and 30 percent. It took competitive long distance companies 10 years to achieve a 30 percent penetration after the introduction of

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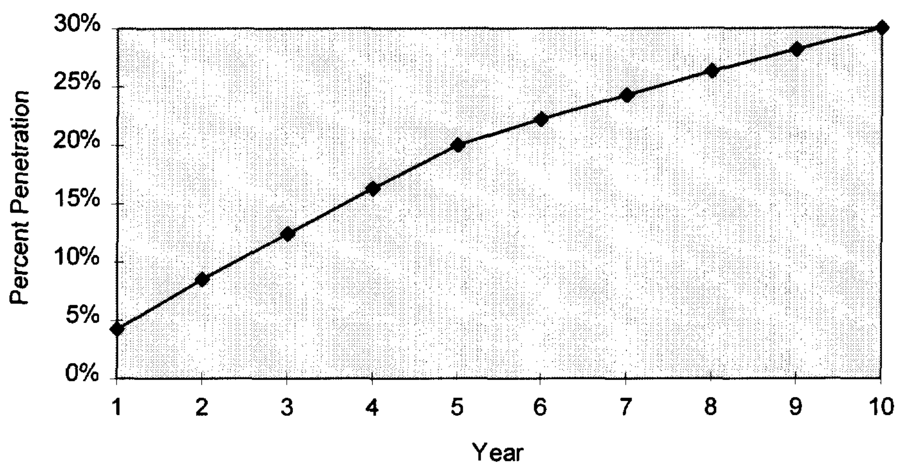
[61] See, <u>In the Matter of Access Charge Reform</u>, Notice of Proposed Rulemaking, CC Docket No. 96-262, released December 24, 1996.

[62] Some access charge reform proposals contemplate rebalancing that would increase the monthly local exchange service per line rate. Line rates are not increased in the business case as access charge prices are reduced. When embedded advertising, marketing and product management costs are added to the Hatfield TSLRIC rate for the study area, the resulting cost is close to the existing national average residential monthly service charge, suggesting that ILECs can recover their economic costs without rebalancing.

switched competition, despite substantial price discounts and a ballot and allocation process in the early years of competition.[63]

The rate at which the ultimate penetration is achieved has a substantial effect on the business case results; achieving penetration more rapidly improves the business case. Instead of assuming a linear growth in penetration over the ten-year study period, an optimistic assumption is made that two-thirds of the ultimate penetration is achieved after five years. Figure 5 illustrates the penetration growth assumption for the 30 percent penetration case.

Figure 5
Cable Telephony Subscriber Penetration



Current cable telephony penetration in the U.K. ranges between 20 and 30 percent after six years of competition.[64] However, the cable telephony experience in Great Britain cannot be

[63] See Common Carrier Statistics, *supra.*, note 19.

[64] See John Cluny, "Cable Telephony as a Business," unpublished manuscript, presented at 1996 Telecommunications Policy Research Conference.

used as a template for the U.S. market. First, cable operators in Great Britain were able to install wires for telephony at a very low incremental cost because very little cable service existed prior to 1991. Second, in 1990, British Telecom ("BT"), the incumbent carrier, may have still been suffering from its government monopoly legacy.[65] While BT's performance has improved markedly in recent years, cable competitors had a window of opportunity to exploit. As noted above, U.S. cable operators are faced with generally satisfied local telephone service customers and poor customer service reputations of their own. Finally, cable penetration in the UK has not come cheaply.[66] It is not clear that investors in U.S. Cable properties will be so tolerant to these start-up losses.[67]

E. Business Case Results

Three penetration scenarios that range from pessimistic to optimistic are considered in the business case. The parameters that change between scenarios are the tenth-year cable telephony penetration rate, the incremental investment in a two-way active network and long distance usage levels.

New entrants may successfully market to higher than average long distance users in order to maximize revenue. Therefore, a sensitivity analysis on long distance usage is conducted. The sensitivity consists of evaluating the business analysis for two long distance usage levels: average long distance usage and twice the average long distance usage per customer.

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[65] See Lawrence Chimerine and Erik R. Olbeter, Lessons From Abroad: Deregulation Efforts in New Zealand and the United Kingdom (July 1995), p. 27.

[66] See Merrill Lynch, Telewest (January 17, 1997), p. 13.

[67] For a detailed description of cable telephony in the U.K., see, Cluny, *supra*, note 64.

When average long distance usage levels are considered, the per subscriber monthly revenues average $33 in year one and taper to $24 by year five of the study period due to reduced access and vertical services revenues. By year ten, revenue per subscriber increases to $26. Doubling the long distance usage increases the per subscriber monthly revenues to $40 in year one, which taper to $26 by year five and gradually increase to $29 in year ten. The revenue increase that occurs toward the end of the period is due to increasing long distance usage (7 percent per year) and the increasing take rate of second lines.

Running the business case analysis for the market penetration and sensitivity cases discussed in the preceding section yielded the results in Table VI. An investment in cable telephony does not turn the cumulative operating cash flow positive until the eighth year in the most optimistic scenario.[68]

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[68] Robert Crandall and Leonard Waverman report that "... cable telephony has a lower revenue requirement than even the most efficient, rebuilt wire-line telephone network." See Talk Is Cheap (1996), p. 243. By assuming 100 percent penetration, Crandall and Waverman grossly understate cable telephony costs per subscriber likely to be realized in the real world. Moreover, based on Hatfield Model results, their forward looking estimate of per subscriber investment costs for telephone companies is overstated by almost 30 percent.

Table VI

Cable Telephony Business Case Results				
Case	Telephony Penetration	Years to Positive Cumulative Operating Cash Flow	IRR	Cumulative Cash Flow Per Subscriber, Including Investment (tenth year)
Adding Telephony to a Fiber-Rich System, Twice the Average Long Distance Usage				
1	10%	9	-12.8%	-$708
2	20%	7	-2.9%	-$114
3	30%	7	2.6%	$84
Adding Telephony to a Pre-existing HFC System, Average Long Distance Usage				
4	10%	10	-4.2%	-$103
5	20%	8	5.7%	$118
6	30%	8	10.2%	$191
Adding Telephony to a Pre-existing HFC System, Twice the Average Long Distance Usage				
7	10%	9	1.5%	$39
8	20%	7	12.4%	$260
9	30%	7	17.5%	$334

The ten-year internal rate of return on the three projects are, respectively, 1.5 percent, 12.4 percent, and 17.5 percent, even in the case where an HFC network is already in place and long distance usage is twice the national average. It is likely that investors would require a substantial expected IRR for a project with the level of risk associated with entering a market dominated by the ILECs. Only the most optimistic case passes the 15 percent hurdle discussed earlier. Moreover, investors risking millions of dollars of capital would likely make less optimistic cost and revenue assumptions than are made in this analysis.

F. Cable Telephone Qualitative Factors

Given these results, it is no surprise that TCI and Time Warner, the two largest cable multiple system operators that together pass more than 37 million homes, have recently announced that they are reducing their emphasis on telephony.[69] These announcements are especially interesting because they originate from MSOs that once had ambitious plans for telephony. This point is made clear in a recent statement by John Malone, CEO of TCI, who says, "you read our annual report last year, you'd think we were one-third data, one-third telephone, and one-third video entertainment, instead of 100% video entertainment and two experiments."[70] And, "Right now we've got zero revenue from residential telephone service, diminishing revenue from high-speed Internet, and $6 billion in revenue from video entertainment."[71] These statements clearly indicate that ubiquitous, competitive cable telephony is not "right around the corner."

There is a real question about whether cable telephony will attain the critical mass that is necessary to establish cable operators as an alternative local exchange provider. Analysis of the qualitative factors cable telephone providers face, coupled with the business case, suggest that it will not, at least in the near term. Significant presence and penetration will be required before residential customers of the ILECs begin to feel comfortable with the quality and level of service

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[69] See, Mark Robichaux, "Malone Says TCI Push Into Phones, Internet Isn't Working for Now," The Wall Street Journal (January 2, 1997), or David Lieberman, "Small Step to Riches has Become Costly Leap of Faith," *supra.*, note 12, p.1A.

[70] Mark Robichaux, "Malone Says TCI Push Into Phones, Internet Isn't Working for Now," *id.*

[71] *Id.*

provided by cable telephony operators. It will be especially difficult for cable operators, who cannot really afford to offer discounted prices for commodity services, to reach this level of critical mass, given the ubiquity, reliability, quality, and customer satisfaction with existing residential local exchange service. Unless this level of critical mass is achieved and consumers begin to feel comfortable with cable telephony, many individuals will not consider taking a chance on a non-established provider.

G. Cable Data Considerations

The fact that many cable operators are considering entry into the broadband data business by providing cable modem access to residential subscribers does not alter the fundamental conclusion of this analysis.[72] It might be thought that successful entry into the data communications business would position the cable operator for inexpensive entry into voice grade telephony. This is not the case. To provide telephony, a cable operator must invest in CIUs, HDTs, backhaul electronics, back-up power, and switching even if it is already offering data service. Furthermore, telephony requires substantial additional expenses.

The grade of service for residential broadband data can be much lower than the grade of service for voice communications. Due to the nature of residential data communications services, momentary service interruptions may very well go undetected by an end user. Data in the form of Internet access are different than telephony because a series of protocols mitigate errors (i.e., if a noise burst on the cable causes an error in a packet, the protocols correct the

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[72] Although broadband data represent an important opportunity for cable operators, entry into the data business does not change the telephony business case analyzed in this paper. At least today, broadband data and telephony share network facilities only. Once the network is in place, all the incremental equipment investments are unique to each service.

packet using forward error correction or the receiving equipment asks for a repeat). The end user is completely unaware of this situation. This is in contrast to voice over cable networks where interference may cause calls to be dropped or generate intermittent service interruptions during a conversation. Moreover, unlike traditional local exchange service, residential subscribers do not rely on data communications services in life-threatening situations, and they are accustomed to losing all data services when the power fails. Residential data services do not bring with them the same public safety issues as residential voice service, and, as a result, the costs of maintaining the network to support these services and subscriber expectations of broadband data are reduced.

For all of these reasons, penetration in the data services market may be perceived as much easier by the cable operator. While telephone companies provide excellent voice service, the perception is that their data services are lagging. ISDN is expensive and not widely available. Dedicated digital circuits can be difficult to procure on a timely basis from some telephone companies. On the revenue side, some cable operators are charging 150 dollar installation fees plus 35 dollars or more per month for access and Internet usage. Cost-based telephone revenues for residential voice service are much lower. In other words, there is substantial pent-up demand for cable modem service and virtually no pent-up demand for voice grade service. This discussion, together with the business case results shown above, suggest why there is more interest in cable operator movement into the data business than the voice business.

VII. WIRELESS LOCAL LOOP BUSINESS CASE ANALYSIS

This section describes the model and the business case for analyzing the competitive potential of WLL, and defines several qualitative considerations. WLL will be modeled in a configuration that is as close a substitute for residential wired local loop services as can be reached, given the state of current wireless technology. The same study area employed in the cable telephony model is used in the wireless model.

The radio spectrum and technology options that might be used by a service provider to implement residential telephone service in the service area are identified and a modeling decision is made in Section A. Based on the spectrum and technology selected for modeling purposes, the capital investments and associated operating and subscriber acquisition expenses are then projected in Section B. Demand and revenue assumptions are made in Section C. The demand, revenue and cost information are integrated in the WLL model to develop the per-subscriber capital investments and associated expenses. The business case for this alternative local exchange telephone service is presented in Section D. Finally, several significant qualitative factors not captured by the business case are discussed in Section E.

A. WLL Spectrum and Technology Options

Given the need for a significant amount of radio spectrum to implement a WLL service, in the United States there are realistically only two potential WLL service competitors in the next few years: Personal Communications Service (PCS) carriers and cellular carriers.[73] WLL

[73] There are other spectrum holders and potential spectrum holders that have indicated they may provide a fixed WLL service. These include holders of MMDS, LMDS and DEMS licenses in the 2.4 GHz, 28, GHz and 24 GHz range. Participants in the current Wireless Communications Service ("WCS") auction could also provide a fixed WLL service. The spectrum for most of these services is yet to be completely allocated and the technology is also still in development. Furthermore, all indications are that these services will be high bandwidth, providing capacity more suited to businesses or video services, with voice for residential customers being a secondary consideration. While it will be interesting to watch these services develop, none of them will have widespread, ubiquitous availability by the year 2000.

entry by a PCS provider with a 30 MHz license will be modeled here for three reasons: 1) recent PCS auction winners hold the largest amount of unencumbered spectrum (up to 40 MHz); 2) they have a "greenfield" business and technology opportunity with no legacy systems to maintain or customer base to protect; and 3) PCS carriers are likely to seek alternative revenue sources due to competition from other mobile service providers.

It is unlikely that cellular carriers will pursue WLL services for several reasons. They currently operate analog networks optimized for mobility with limited available capacity. Many of these systems are in the process of being upgraded to digital technology for added capacity and features, but the upgrade to digital is made problematic by having to maintain capacity for increasing demand from their installed analog base. Furthermore, a number of operators have overlaid a packet data services network over their voice oriented network -- adding an additional layer of complexity to the digital conversion. In theory, once the conversion to digital networks is complete, the cellular carriers would have ample capacity to implement WLL; however, the transition to a digital network will fundamentally change the way that the network transports voice signals, to the detriment of transporting subscriber data.[74] In any case, the all-digital cellular network is a number of years away -- beyond the time frame of this analysis.

Enhanced SMR ("ESMR") carriers are even less likely to pursue WLL services. ESMR operators have less spectrum than cellular carriers and most PCS carriers. ESMR technology and networks are optimized for workgroup communications (one to one or one to many) and their marketing structures are oriented to commercial systems sales, as opposed to consumer

[74] The compression of digitized voice for spectrum efficiency purposes severely limits the speed of dial-up data and facsimile transmissions.

sales. While their focus could be turned to WLL, given their current network optimization and market focus, it is unlikely they would deviate from their current strategy.

PCS providers have a number of technology options for putting to use the spectrum acquired in the FCC auctions. Generally, the technology falls into two categories, "High Tier" and "Low Tier." High Tier PCS technology options are essentially cellular protocols, shifted up in frequency to the 1.8 GHz range of PCS ("up-banded"). These include CDMA (IS-95), GSM (PCS 1900), and IS-136 (TDMA).[75] These technologies can be broadly characterized as being designed for high mobility -- allowing handoff at high vehicle speed, employing expensive and complex high traffic capacity cell sites, having specialized switch technology, and requiring extensive network planning and engineering.

Low Tier options for implementing PCS in the United States include PACS (Personal Access Communications System) and Ericsson's Supercordless. PACs is similar to the Personal Handyphone System (PHS) in Japan, while Supercordless is based on the Digital European Cordless Telephone (DECT) standard. Low Tier technology is oriented more towards pedestrian traffic; thus it has a limited ability to hand off calls as the user traverses the network at highway speeds. However, this technology can use standard ILEC switching, has a less expensive and complex network structure, employs simpler and less expensive radio site technology, has generally better voice quality, and allows higher dial-up data rates than High Tier.

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[75] CDMA stands for Code Division Multiple Access, a spread spectrum based protocol. GSM stands for Global System for Mobility, originally the European digital cellular standard. TDMA stands for Time Division Multiple Access, which was developed as the next generation digital cellular standard for North America (as GSM was intended for Europe).

For purposes of this analysis, a High Tier CDMA network will be modeled. Although a Low Tier technology might be a better technology choice for implementing WLL, marketplace realities dictate the selection of CDMA.[76] Based on announcements by PCS auction winners, more of the population will be served by CDMA technology than any other. All auction winners save one in the first PCS auction have announced they will use High Tier technology, with CDMA having the broadest announced coverage.[77] In the second PCS auction, the winner of the most populous licenses has announced CDMA, and the runner up has announced GSM.[78] Only two licensees, holding licenses covering less than 5 million people, have announced they will use PACs technology.[79]

In the recently completed third PCS auction,[80] many of the spectrum winners are previous winners who have already committed to High Tier technology.[81] Furthermore, many of

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[76] There are also technologies designed specifically for Wireless Fixed Access, with no mobility capabilities, which are being implemented in other countries. AT&T has recently announced such a technology for use in the United States, though few details are available. *Supra*, note 8. However, as noted, the near-term marketplace choices in the United States have indicated that PCS spectrum and technology are the most likely sources of WLL offerings. Furthermore, many of the same issues arise whether a totally fixed wireless technology or a mobility technology is employed.

[77] One auction winner in Alaska has announced the use of PACs technology. This equates to one out of 102 license blocks, or less than 1 percent. On a population basis it is less than .2 percent.

[78] NextWave and Pocket Communications, respectively.

[79] 21st Century Telesis and WindKeeper.

[80] Blocks D, E, and F; each with 10 MHz of spectrum, which by all indications is enough spectrum to field a technically competitive PCS network.

[81] Notably AT&T and Sprint. As noted previously, AT&T has also recently announced a fixed wireless local loop technology. They intend to use the fixed WLL system to provide

the other winners will likely choose a more proven High Tier technology, hoping to fill a hole in the nationwide coverage of a particular technology.[82] Any remaining winner(s) in a market may elect to implement a Low Tier technology, but they are at best 12 to 18 months away from commencing operation.[83]

Moreover, CDMA provides some technical advantages for a PCS carrier considering WLL entry. First, CDMA claims the highest subscriber capacity of all High Tier PCS technologies. Second, WLL promotes greater efficiencies in CDMA than in alternatives such as GSM. WLL does not require handing off phone calls between cells as a mobile user crosses the network. Since CDMA uses up to an estimated 40 percent of available capacity for hand-offs, by using a technique called "soft hand-off," a fixed location application such as WLL reclaims that capacity.[84]

It must be noted that there are potential drawbacks to the use of CDMA for WLL. First, CDMA has been delayed coming to the market due to technology development issues. Although

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competitive local exchange service. They are predicting commercial deployment in 18 to 24 months.

[82] For example, becoming the only ISM-136 TDMA operator in Farmington, NM - with all the other licensees having chosen CDMA or GSM.

[83] Electing to employ Low Tier technology does not necessarily mean WLL entry, and if WLL service is entered, it would be years before there is significant market penetration and consequent market erosion of the ILEC position. Further, many of the winners in the most recent PCS auctions are ILECS (US West, AllTel, Bell South), and may become the Low Tier technology operators - potentially putting the ILEC into the WLL business.

[84] This regained capacity is somewhat offset by the need to provide a higher grade of service to WLL users than to mobile users. The grade of service is increased by making more radio channels available for WLL traffic than would be available to an equivalent amount of mobile traffic.

these now seem largely resolved, the development of ancillary applications -- such as WLL -- has been commensurately slowed. Second, the Customer Interface Units (CIUs) needed for interfacing premises wiring to CDMA networks (more fully discussed below) will not be available in large quantities until late 1997 or 1998.[85]

Third, there has been a question of the adequacy of voice quality in digital PCS systems. However, the recent introduction of enhanced 13 kbps vocoding technology has significantly improved the perceived voice quality.[86] Finally, CDMA, like other High Tier PCS technologies, currently provides slower subscriber dial-up data rates than wired loops (14.4 kbps vs. 33.6 kbps).

B. Wireless Local Loop Investment and Expenses

A critical assumption of the model is that the PCS carrier will build out its network for mobility purposes. *WLL will be an incremental service.* Therefore, only incremental costs (and revenues) will be included in the model. This implies that all spectrum acquisition, cell site construction and acquisition, switch installation costs, etc. are considered sunk costs associated with mobility services, not WLL.

For purposes of estimating the number of cells that will have to be equipped for WLL service, the model breaks down the population of the same study area used in the Cable Model by population density. For each segment of population density a different sized cell site is

[85] There have been other issues raised regarding the viability of CDMA. Ericsson has information on its web site addressing concerns about CDMA (www.ericsson.com /Connexion); also see "Jacobs Patter: An Inventor's Promise Has Companies Taking Big Cellular Gamble," Wall Street Journal, (September 6, 1996), p. A1.

[86] 13 kbps CDMA will be used in the WLL model.

deployed, varying by size of coverage area. The denser the population, the smaller the cell coverage area. This automatically introduces incremental traffic capacity into the more densely populated areas. Short of doing an actual specific network design, this is an acceptable means of approximating the number of cells needed to cover a study area, which in turn will be used to determine certain capital costs.

Table VII defines the population densities and related cell sizes used in the model. Note that very sparsely inhabited areas are not provided with coverage in the model.[87]

Table VII

Population Density and Cell Size				
Population Area	Population per Square Mile	Per Cell Coverage For Area (Sq. Mi.)	Square Miles in Study Area	Number of Cell Sites for Area
Dense Urban	> 10,125	1.664	35.13	22
Urban	> 3,060	2.6	119.29	46
Suburban	> 432.5	13.163	222.15	17
Rural	> 102.5	78.650	63.23	1
Uninhabited	< 102.5	N/A	12.13	N/A

As is the case with the cable telephony model, the WLL Model assumes that traffic is in balance and local number portability is in place.[88] Subscriber monthly pricing is flat rate with

[87] This deviates from a true network design somewhat; a sparsely populated area could have a highway through it that could justify coverage.

[88] Early anecdotal support of the reasonableness of a balanced traffic assumption has come from the first operating PCS system in Washington, D.C. The first minute of an incoming PCS phone call is not billed, and mobile phone traffic has achieved a 60/40 outbound-to-incoming balance, which differs from the cellular norm of approximately 80/20. Fixed

unlimited local inbound and outbound calling when the PCS service is used for WLL from the CIU, or within a pre-defined home service area. If the subscriber also has a portable PCS handset, it is likely that the service provider will have a separate pricing scheme for mobility service when the subscriber is away from the home service area. These potential mobility revenues are not considered in this business case. Revenues and expenses are kept constant over time, with some exceptions. As in the cable model, access charges are assumed to move to cost over five years. CIU cost is adjusted downward over time to account for increasing production volumes and efficiencies.

1. WLL Network Architecture

Figure 6 shows the network architecture assumed. It is essentially a common cellular network design, optimized for handheld phones (which PCS users will have). This type of network inherently has substantial traffic capacity because the additional cell sites implemented to provide adequate coverage for the low power handsets result in network capacity as a byproduct.

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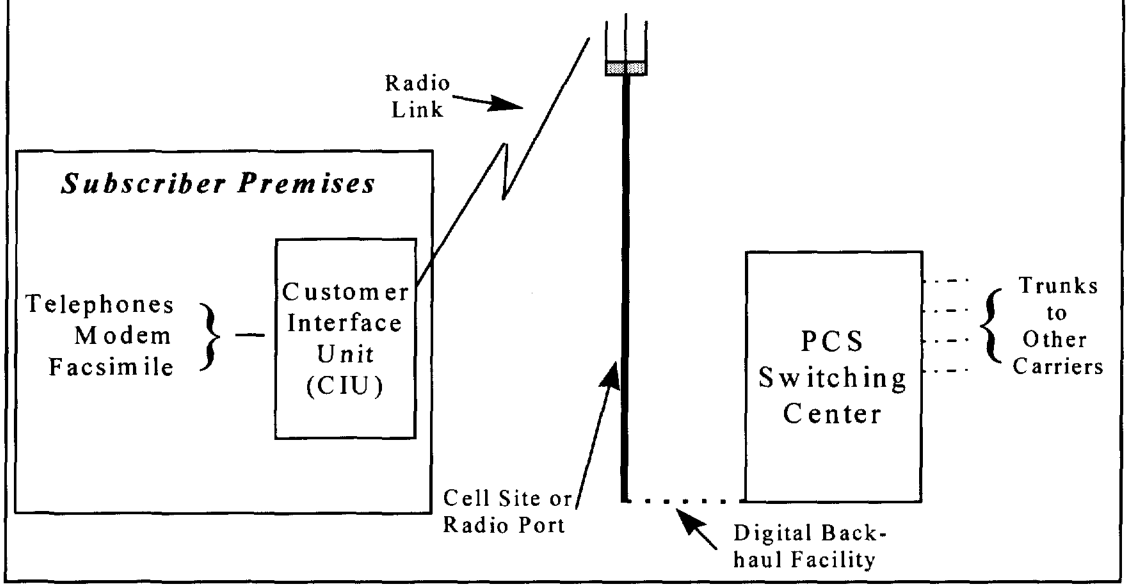
applications could expect traffic even closer to balance.

Figure 6
Generic WLL Network Diagram



The major addition to the network architecture for WLL service is the introduction of a Customer Interface Unit (CIU) at the subscriber's premises (though an integral part of the network, for purposes of the model it is considered a subscriber acquisition expense). The CIU provides an interface between subscriber premises wiring and CPE (phones, answering machines, faxes, etc.) and the radio link to the PCS cell cite. The cell sites are connected to digital backhaul facilities that, at the distant end, are connected to the PCS switch.

The CIUs also generate dial tone and support one telephone number. It can be mounted inside or on the outside of the customer's premises and is powered from the subscriber's residential power source, and will include a battery backup.[89]

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[89] The need for a battery in the CIU presents a further layer of issues. Batteries require maintenance and eventual replacement and disposal; thus the issues are not only one of cost, but of maintenance planning and environmental safety.

The CIU is an incremental expense of telephony. As with cable telephony, when a new subscriber orders service, a technician must physically install the CIU at the customer premises. No subscriber receives a CIU until service is ordered. Therefore, the CIU and installation costs are treated as customer acquisition expenses. In the analysis, these costs are estimated to be $360 and $50, respectively, for the one line unit.

This CIU cost estimate is conservatively low, based on the assumption that a PCS carrier vigorously pursuing a WLL strategy will commit to unit counts in sufficient quantities to gain significant discounts. As of this writing, the least expensive price for a CDMA CIU is $600, based on information from Qualcomm, the leading developer of the technology. This price was provided as an estimate, with a strong caveat that volumes would drive significant discounts. Thus, a discount of 40 percent is used at the outset. The price is reduced over time on the assumption that it will follow a standard curve of declining product prices as volumes rise and manufacturing efficiencies develop. This pricing assumption has been confirmed in discussions with other PCS equipment manufacturers.

The PCS switch, in this application, is the functional equivalent of the ILEC end office. This switch will have trunk side connections to ILEC local and tandem offices and to IXC points of presence. Eventually it will also connect to other CLEC facilities. This switch also provides an interface to voice messaging facilities, short messaging service facilities that are part of the PCS protocol, and to other adjunct processors that manage mobile traffic operations such as hand-off and user validation.

2. Incremental Network Capital Costs

The principal network-based capital costs for WLL service are added radio frequency channels at cell sites for WLL traffic. Incremental traffic capacity for WLL is segregated from mobility capacity to facilitate the necessary lower blocking probability in accessing switching.[90] Residential phone usage offers more busy hour traffic than mobile usage, .1 Erlangs for residential users versus .02 Erlangs for mobile users, translating to more required traffic capacity per subscriber. In addition and as noted, residential users (indeed all wireline users in the United States) have very high expectations of getting dial tone every time they pick up the phone. Thus, channels for WLL service have to be implemented in a quantity greater than for mobility to attain a lower blocking probability for WLL -- 0.1 percent versus 2 percent for mobile services.

For purposes of the WLL model, the assumption is that each radio channel can handle 17 simultaneous conversations (which incorporates the 40 percent gain from eliminating hand-off).[91] Additional channel capacity for WLL service is installed uniformly throughout the modeled territory in anticipation of a mass media marketing campaign.

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[90] Arguably, combining channels for mobility and WLL service could gain trunking efficiencies and provide greater total capacity. However, mobility traffic can be very peaked. For instance, mobile subscribers in vehicular traffic stalled due to a snowstorm or accident can quickly tie up every available PCS channel. This could block WLL users, who have high expectations of always getting a dial tone - lack of which could be disastrous for a WLL service provider.

[91] One of the attractive features of CDMA is, due to the spread spectrum modulation technique employed, in theory every frequency can be used at every site. This provides adequate capacity for both WLL and mobility traffic in the penetration levels modeled. Additional capacity can always be attained by implementing more spectrum, if available, or adding more cell sites.

The cost per radio channel is $25,000. For every voice path on the radio channel there is an additional cost of $100. Cell sites are managed by Base Station Controllers (BSCs). For each radio channel implemented there is an incremental cost of $7,000 at the BSC. Thus the total cost for a radio channel equipped for 17 voice paths, including BSC costs, is $33,700. A BSC costs $360,000 and can handle 5,000 voice paths. Once more than 5,000 voice paths are needed another BSC must be put in place.[92]

3. Wireless Local Loop Expenses

A number of expense elements are the same as the cable telephony model. They include switching expense, plant-specific network expenses, building expense, network support expense, ILEC interconnection expense, billing, billing inquiry, local number portability expense, directory expense, uncollectible expense, overhead, and other taxes expense.

The following expenses used in the WLL model differ from those in the cable telephony analysis:

<u>Backhaul from Cell Sites to the BSC</u> The model assumes T1 circuits are used to bring traffic back to the BSC and switch. A PCS carrier could put in its own microwave network to carry all or part of this traffic. However, without explicit knowledge of microwave frequency availability in a particular market, the PCS network topology and capital funds available, it is

[92] These costs are based on conversations with equipment manufacturers and prior HAI modeling and research.

impossible to determine what the mix of owned versus leased facilities would be. Therefore the model assumes T1 circuits are leased at a cost of $300 per month, per circuit required.[93]

CDMA backhauls traffic at the vocoder rate of 13.4 kbps, allowing for greater efficiency in digital backhaul facilities. The model increments T1 circuits only as growing subscriber penetration and resulting traffic demands require additional radio channels and voice paths be implemented.

<u>Network Operations Expense</u> It was assumed that providing cable telephony services would result in substantial incremental power, testing, operation, engineering, and network administration expenses because these functions are much simpler for a cable-only system. In contrast, adding network operations for WLL to a mobility system would likely not be as expensive. Therefore, this expense category is ignored for purposes of the business case.

<u>Customer Acquisition Expense</u> This category aggregates a number of separate expenses. The most significant is the cost of the CIU. Although PCS carriers to date have been successful in not having to heavily subsidize subscriber handsets from usage revenue (unlike cellular carriers), that will not apply to the CIU. Typically, a subscriber does not currently pay an extraordinary up-front cost for wired local loop service, and would resist doing so for WLL. Therefore the carrier must bear the cost of the CIU as a customer acquisition cost. The cost of

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[93] This information is based on recent research Hatfield Associates has done on retail urban digital connectivity options, which differs from the Hatfield Model which determines ILEC costs for their own facilities. The $300 per circuit is an estimate of what the average cost would be for a number of circuits of various length leased from a variety of ILEC and CAP sources. On a time to market basis, leasing T1 capacity may be faster than getting a microwave system licensed (and the costs for each over a ten-year period are not tremendously different). In either case, backhaul, though a critical component, represents only two to four percent of total expenses in the model.

the CIU is $360 for the first year of the model, and declines by 10 percent each year to account for economies of increased production and competition.

Although the model assumes WLL to be incremental for a PCS carrier already in a market with advertising, sales programs and sales staff, it cannot be assumed that there would be no incremental acquisition costs for WLL. The penetration levels modeled could not be reached without some marketing and sales effort. There will have to be sales promotions, targeted and mass-media advertising, and subscriber retention programs. Coordination of WLL service provisioning must also be accounted for.

The model also applies a one-time expense of $250 for every new subscriber added, plus the cost of the CIU and installation. The $250 figure is lower than what has been quoted by investment research analysts for PCS customer acquisition.[94]

C. Demand and Revenue Assumptions

Demand is measured by market penetration, as a percentage of population (POPs). The WLL model is based on POPs (not households) as it is the standard for the wireless industry. WLL penetration will lag behind mobility penetration (generally projected at 5-10 percent of POPs per 30 MHz PCS license after 10 years). WLL penetration rates per carrier of 2.5, 5 and

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[94] Wireless in the United States: The Next Generation (March 1996), a report produced by Merrill Lynch, estimates a beginning marketing expense per gross PCS addition of $325, which declines to $210 after ten years (p. 12). The Wireless Communications Industry (Summer 1996), produced by Donaldson, Lufkin & Jenrette, notes a similar expense to be $2500 in year one, declining in the next year to $600, and to $250 by the tenth year (p. 26).

7.5 percent are modeled. Note that with up to 8 PCS and cellular carriers in a market, this implies total potential WLL penetration of up to 60 percent (a highly unlikely event).[95]

The model assumes the same subscriber growth pattern as the cable analysis; that is, WLL subscriber growth is rapid at the beginning of the study period and then tapers off. There is subscriber churn included. Given the importance of local exchange service to subscribers, and the fact that an installer's visit is required (which complicates changing service providers), a lower churn figure than the standard 2 percent per month cited for cellular is assumed. The model uses .5 percent per month. Furthermore, the model assumes 75 percent of the CIUs are recovered from subscribers discontinuing service. These CIUs are recycled and represent an avoided cost in acquiring subsequent subscribers.

Monthly service charges were based on the national average rate of $19.00. To date, PCS operators are generally bundling voice mail service and some custom calling features in with their standard service. Thus, rather than an explicit discount to the average monthly service charge, services that an ILEC would normally charge for are bundled, resulting in an implicit discount.

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[95] An alternative scenario would be one PCS license winner electing to focus only on WLL and providing no mobility services. The penetration numbers could then be similar to those of the cable telephony model, with a potential improvement in business case results. However, as noted, the selection of PCS and CDMA is the result of marketplace circumstance, and there has been no announcement by any PCS licensee of a WLL-only strategy using a technology that is known and deliverable (details on AT&T's announced fixed WLL technology are still not available). Furthermore, the model assumptions would change significantly if WLL is no longer incremental; many of the costs attributed to mobility would be shifted to WLL, while there would be little or no increase in revenue per subscriber.

Assumptions for subscriber traffic, access charges and long distance revenues are the same as in the cable telephony model.

D. Business Case Results

Table VIII below shows the results for the three penetration rate scenarios modeled. As in the cable telephony case, the Internal Rate of Return meets the 15 percent hurdle applied to projects only in the most optimistic scenarios. As indicated in the cable telephony analysis, investors would likely use lower revenue and higher expense assumptions than are used here. Break-even for cumulative operating cash flow is at a point eight years out (although it is not noted in the table, cumulative cash flow including investment does not turn positive until the tenth or eleventh year).[96] The cash flow numbers are also dismal, especially at the lowest penetration level.[97]

[96] As bleak as these returns may seem, they are actually better than were estimated in *ELB I*, which estimated it would be 8 years until operating cash flow even turned positive, let alone recovered cumulative losses. Clearly, we are three years further along and operating with more current data.

[97] The IRR for Scenario 2 reflects a timing anomaly in the model. The WLL system is at capacity by the end of year 10, and were the model to go out one more year, or penetration be 1 percent higher, a further $9 million investment in additional capacity would be required. This would adjust the IRR downward to about -5.75 percent. The Cumulative Cash Flow per Subscriber figures also reflect this anomaly. Further, at 7.5 percent penetration, the model shows a significant amount of the potential channels per site are being used for WLL in the tenth year (15 of 36, or 42 percent). It is unlikely a carrier would get to this level of WLL usage (threatening mobile service capacity) without adding cell sites requiring significant incremental expense.